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[54] POWER SUPPLY CONTROL SYSTEM FOR A PORTABLE COMPUTER

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[21] Appl. No.: **929,498**

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Related U.S. Application Data

[63] Continuation of Ser. No. 541,978, Jun. 22, 1990, abandoned.

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Jun. 23, 1989 [JP] Japan 1-162231
Jun. 23, 1989 [JP] Japan 1-162234

[51] **Int. Cl.**[5] **G06F 1/00**
[52] **U.S. Cl.** **364/707**; 364/708.1
[58] **Field of Search** 364/707, 708; 371/66

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,667,289	5/1987	Yoshida et al.	364/707 X
4,769,764	9/1988	Levanon .	
4,788,658	11/1988	Hanebuth .	
4,858,162	8/1989	Kieffer et al.	364/708
4,945,280	7/1990	Beghelli	315/129
4,984,185	1/1991	Saito	364/707
5,008,846	4/1991	Inoue	364/707
5,021,983	6/1991	Nguyen et al.	364/707

FOREIGN PATENT DOCUMENTS

0273322 7/1988 European Pat. Off. .

OTHER PUBLICATIONS

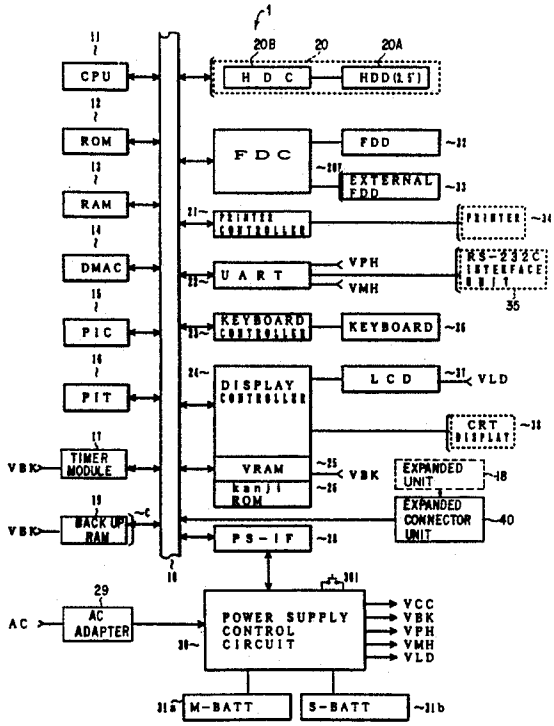
Toshiba T1600 Portable Personal Computer User's Manual (no date).
Toshiba T5100 Portable Personal Computer Reference Manual (No date).
Toshiba T5200 Portable Personal Computer Reference Manual (No date).
"User's Manual, Four-bit Microcontroller and Peripheral Memory, TLCS-47E/47/470/470A" (portions of title are in the Japanese language), pp. 5-211 through 5-223 and unnumbered final page, published by Toshiba Corporation, dated 1991.
Toshiba Desk Station I User's Manual, 1990.

Primary Examiner—Tan V. Mai
Attorney, Agent, or Firm—Finnegan, Henderson, Farabow, Garrett and Dunner

[57] **ABSTRACT**

A power supply control system for a portable computer having a central processing unit (CPU), and operable in response to power supplied from a rechargeable battery or an alternating current (AC) adapter. The control system includes a charge unit for charging the rechargeable battery; current detectors for detecting power status; and a power control microprocessor for controlling the charge unit independently of the CPU in response to a detected power status.

45 Claims, 8 Drawing Sheets



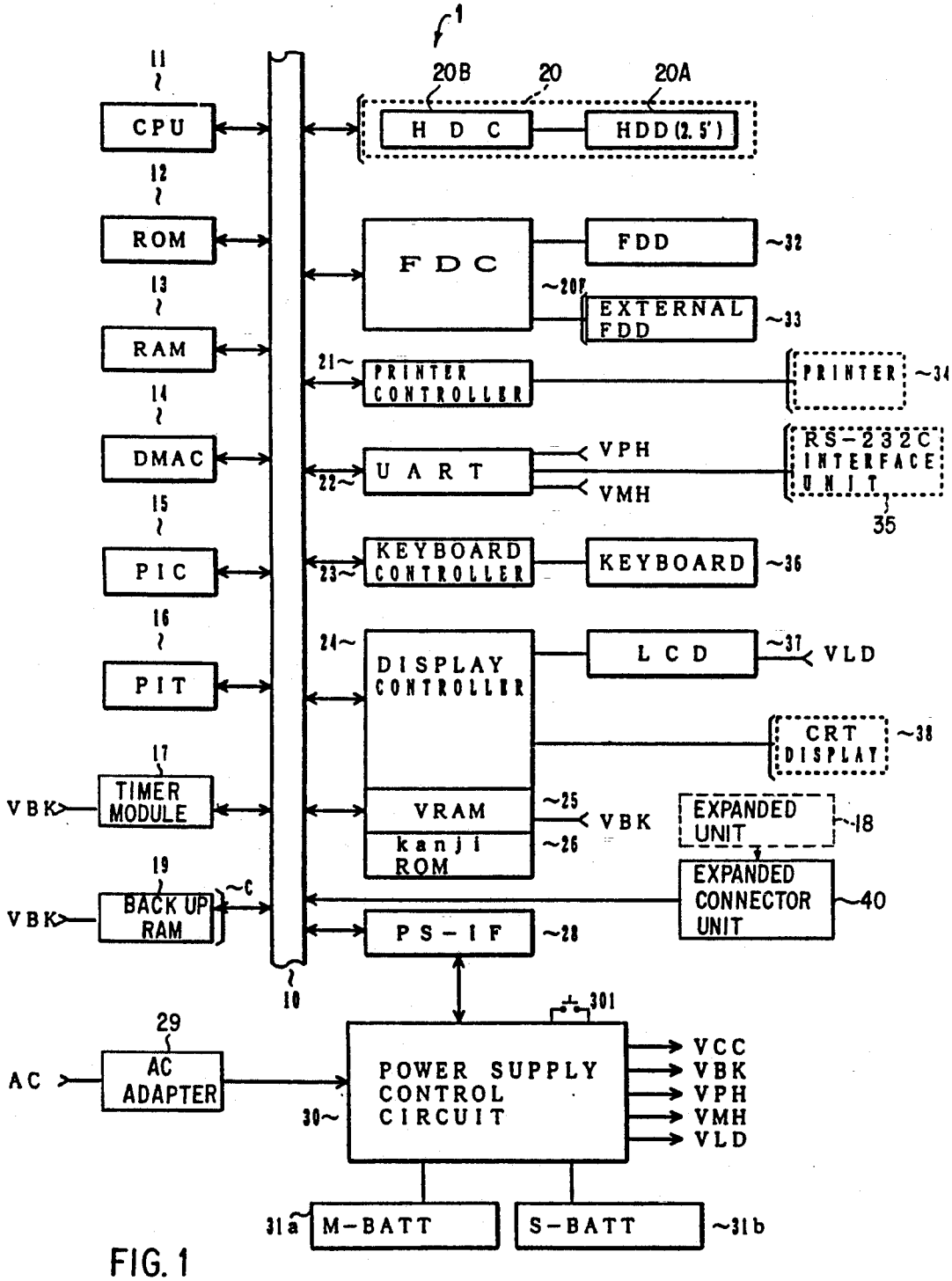

1
11
CPU
12
ROM
13
RAM
14
DMAC
15
PIC
16
PIT
17
TIMER MODULE
VBK
19
BACK UP RAM
VBK
C
10
20B
20
20A
H D C
HDD(2.5')
FDC
FDD
32
20F
EXTERNAL FDD
33
21
PRINTER CONTROLLER
PRINTER
34
U A R T
22
VPH
VMH
RS-232C INTERFACE UNIT
35
KEYBOARD CONTROLLER
23
KEYBOARD
36
24
DISPLAY CONTROLLER
L C D
37
VLD
CRT DISPLAY
38
VRAM
25
kanji ROM
26
VBK
EXPANDED UNIT
18
EXPANDED CONNECTOR UNIT
40
P S - I F
28
301
29
AC
AC ADAPTER
30
POWER SUPPLY CONTROL CIRCUIT
VCC
VBK
VPH
VMH
VLD
31a
M-BATT
S-BATT
31b

FIG. 1

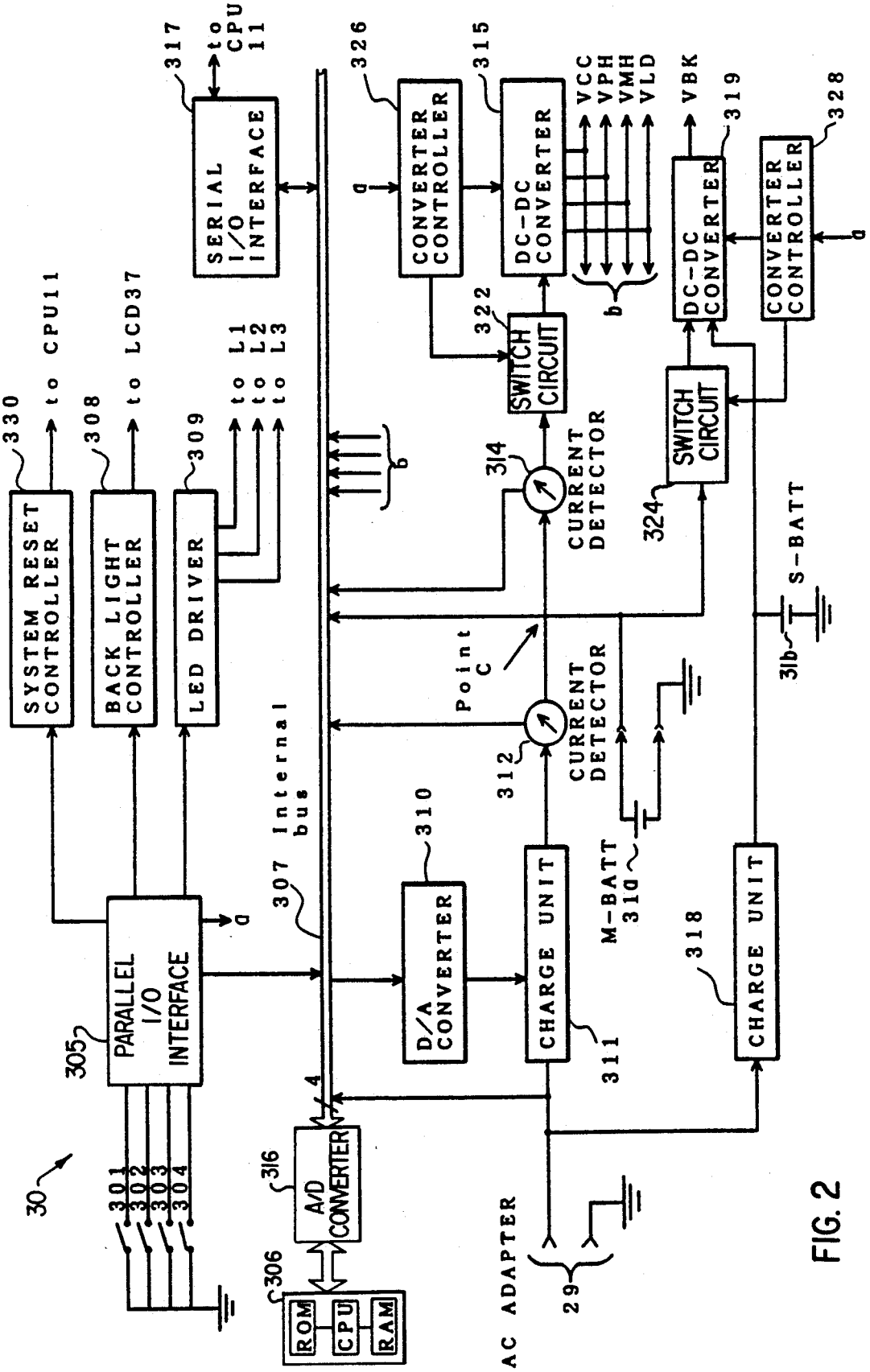

SYSTEM RESET CONTROLLER
BACK LIGHT CONTROLLER
LED DRIVER
SERIAL I/O INTERFACE
CONVERTER CONTROLLER
DC-DC CONVERTER
SWITCH CIRCUIT
CURRENT DETECTOR
PARALLEL I/O INTERFACE
D/A CONVERTER
CHARGE UNIT
A/D CONVERTER
ROM
CPU
RAM
Internal bus
Point C
M-BATT
S-BATT
AC ADAPTER
VCC
VPH
VMH
VLD
VBK
to CPU11
to LCD37
to L1
to L2
to L3
to CPU 11
30
301
302
303
304
305
306
307
308
309
310
311
312
314
315
316
317
318
319
322
324
326
328
29
31b

FIG. 2

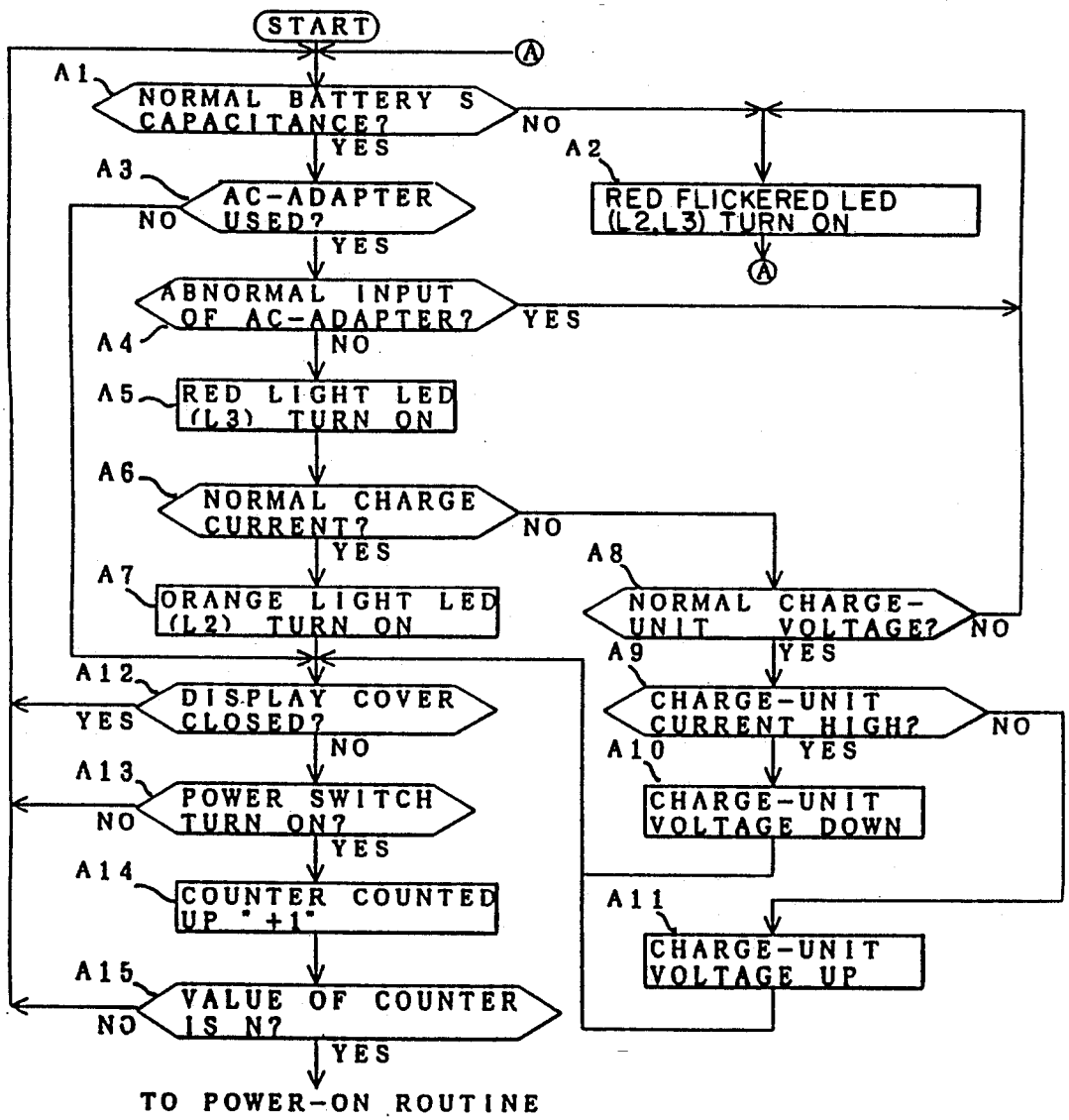

START
A
A1
NORMAL BATTERY S CAPACITANCE?
NO
YES
A2
RED FLICKERED LED (L2,L3) TURN ON
A
A3
AC-ADAPTER USED?
NO
YES
ABNORMAL INPUT OF AC-ADAPTER?
YES
A4
NO
A5
RED LIGHT LED (L3) TURN ON
A6
NORMAL CHARGE CURRENT?
NO
YES
A7
ORANGE LIGHT LED (L2) TURN ON
A8
NORMAL CHARGE-UNIT VOLTAGE?
NO
A9
YES
A12
DISPLAY COVER CLOSED?
YES
NO
CHARGE-UNIT CURRENT HIGH?
NO
A10
YES
A13
POWER SWITCH TURN ON?
NO
YES
CHARGE-UNIT VOLTAGE DOWN
A14
COUNTER COUNTED UP "+1"
A11
CHARGE-UNIT VOLTAGE UP
A15
VALUE OF COUNTER IS N?
NO
YES
TO POWER-ON ROUTINE

FIG. 3

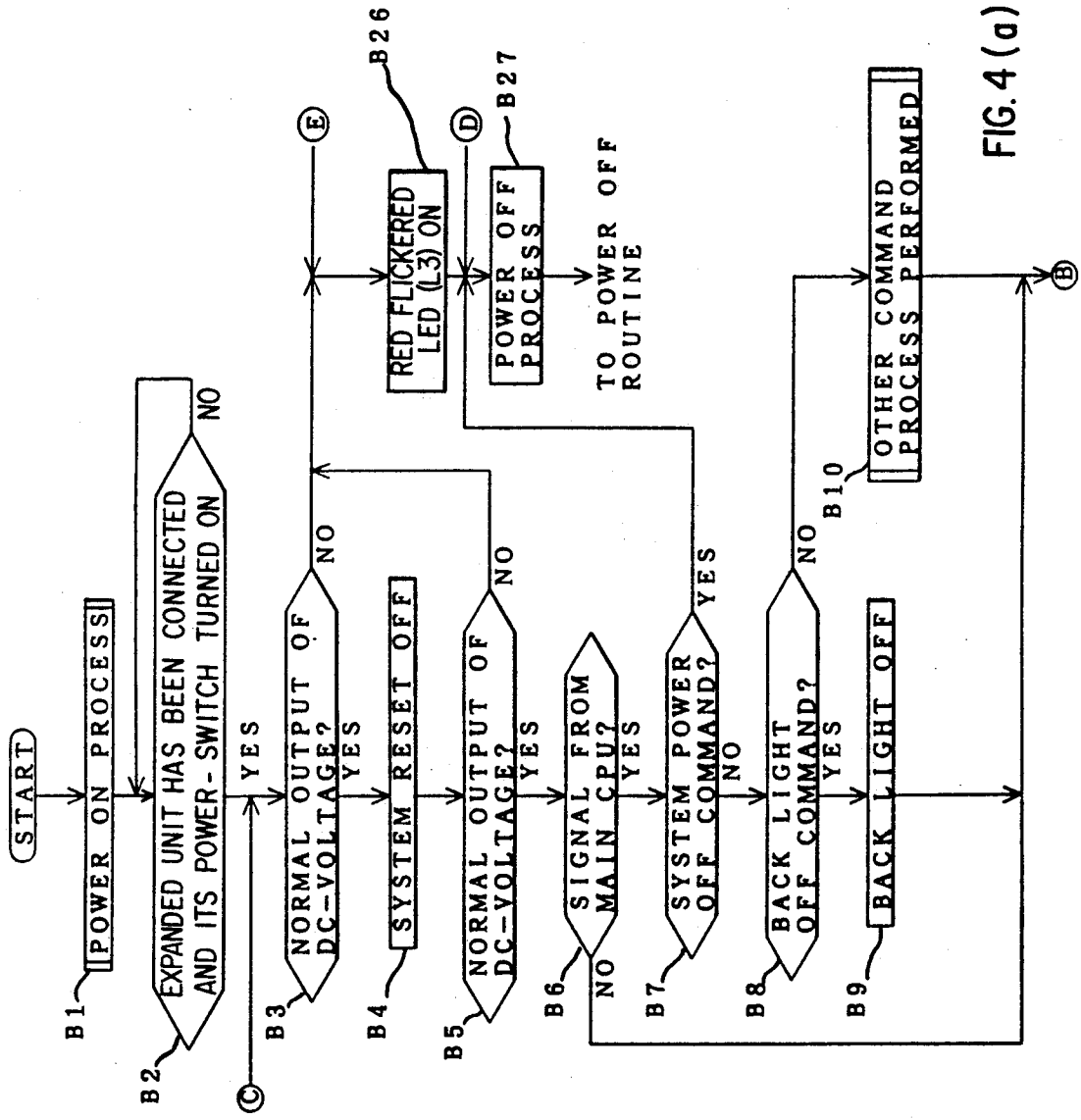

START
POWER ON PROCESS
B1
EXPANDED UNIT HAS BEEN CONNECTED AND ITS POWER-SWITCH TURNED ON
B2
NO
YES
NORMAL OUTPUT OF DC-VOLTAGE?
B3
NO
YES
SYSTEM RESET OFF
B4
NORMAL OUTPUT OF DC-VOLTAGE?
B5
NO
YES
SIGNAL FROM MAIN CPU?
B6
NO
YES
SYSTEM POWER OFF COMMAND?
B7
NO
YES
BACK LIGHT OFF COMMAND?
B8
NO
YES
BACK LIGHT OFF
B9
OTHER COMMAND PROCESS PERFORMED
B10
RED FLICKERED LED (L3) ON
B26
POWER OFF PROCESS
B27
TO POWER OFF ROUTINE
C
D
E
B

FIG. 4 (a)

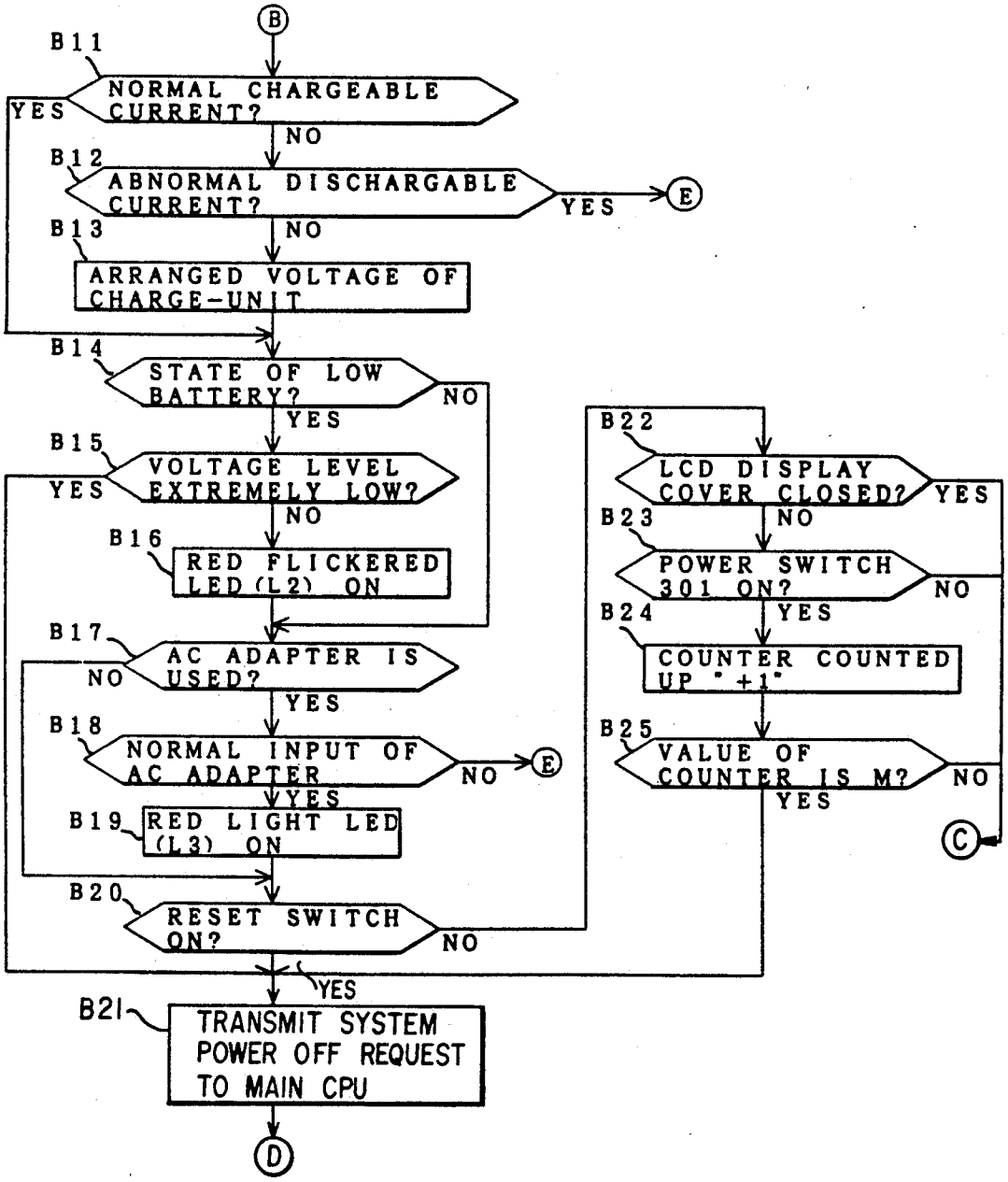

B
B11
NORMAL CHARGEABLE CURRENT?
YES
NO
B12
ABNORMAL DISCHARGABLE CURRENT?
YES
E
B13
NO
ARRANGED VOLTAGE OF CHARGE-UNIT
B14
STATE OF LOW BATTERY?
NO
YES
B15
VOLTAGE LEVEL EXTREMELY LOW?
YES
NO
B16
RED FLICKERED LED (L2) ON
B17
AC ADAPTER IS USED?
NO
YES
B18
NORMAL INPUT OF AC ADAPTER
NO
E
YES
B19
RED LIGHT LED (L3) ON
B20
RESET SWITCH ON?
NO
YES
B21
TRANSMIT SYSTEM POWER OFF REQUEST TO MAIN CPU
D
B22
LCD DISPLAY COVER CLOSED?
YES
NO
B23
POWER SWITCH 301 ON?
NO
YES
B24
COUNTER COUNTED UP "+1"
B25
VALUE OF COUNTER IS M?
NO
YES
C

FIG. 4(b)

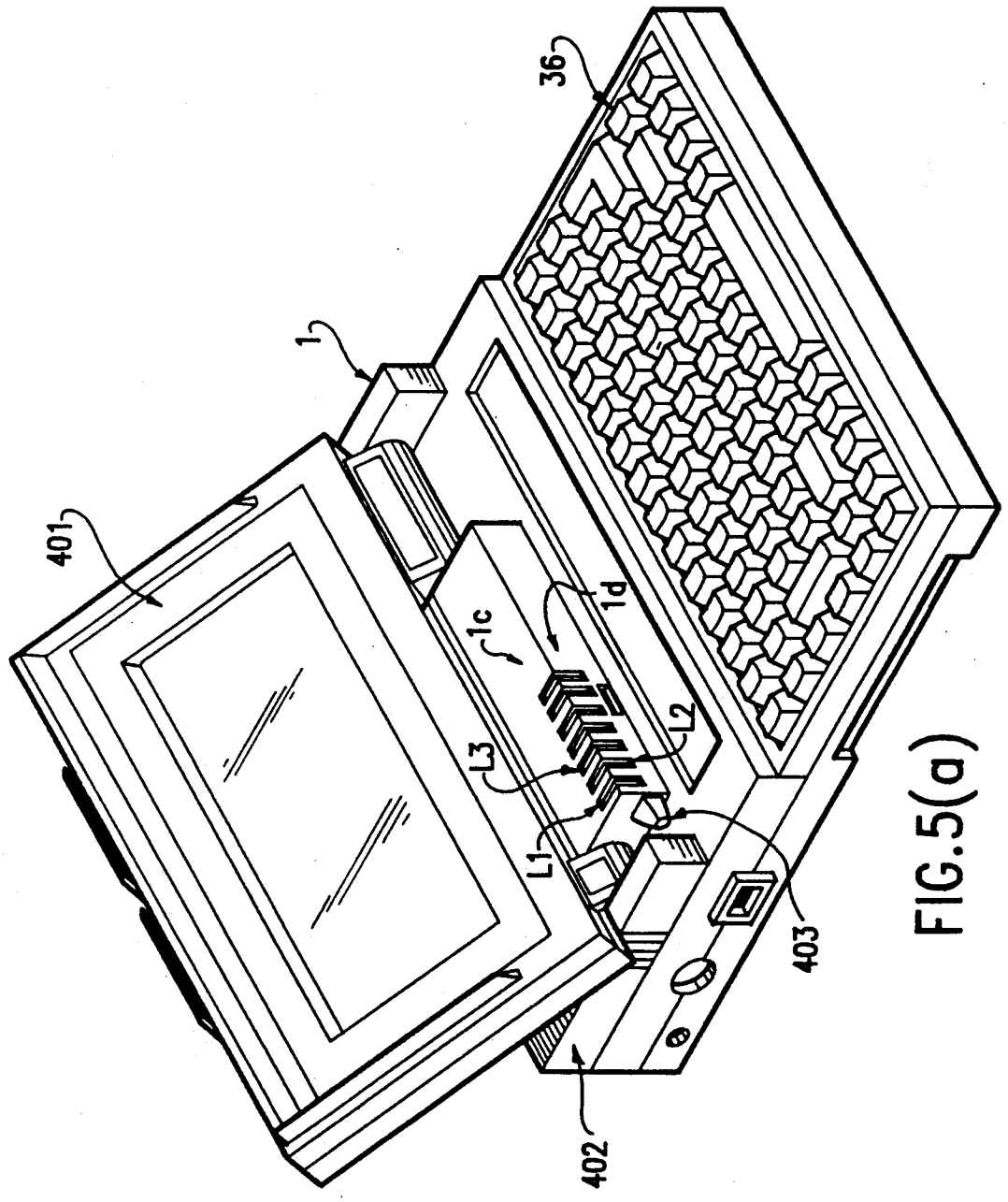


FIG.5(a)

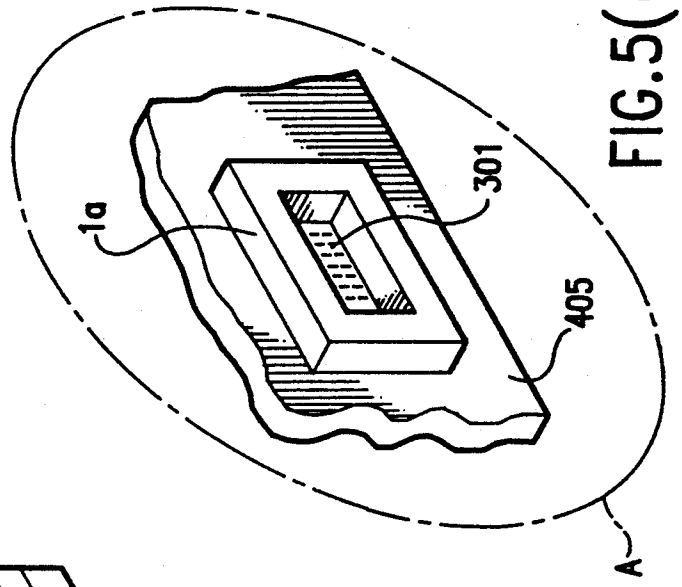


FIG.5(c)

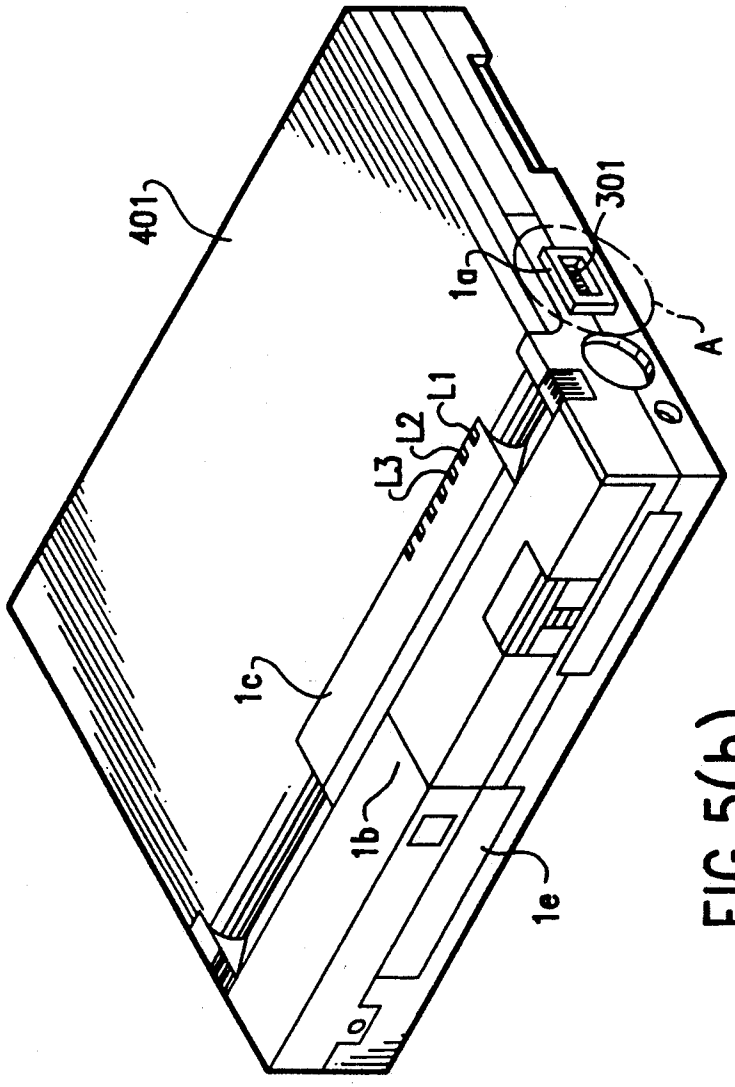
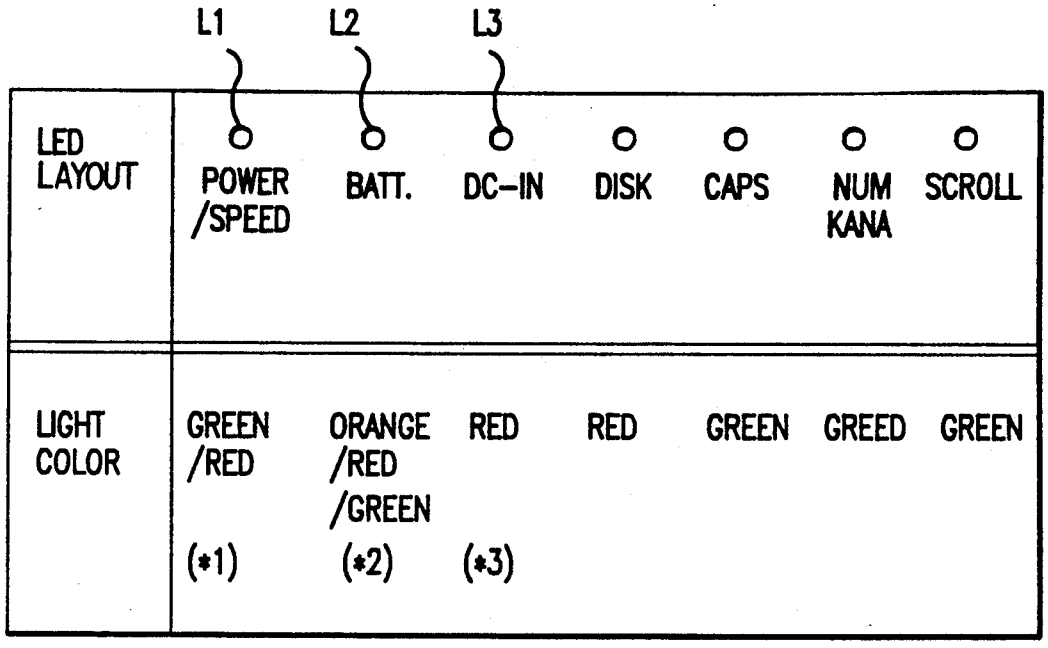


FIG.5(b)



*1 AS CPU ACTUATED AT HIGH SPEED CLOCK "10Mhz", GREEN LIGHT.
AS CPU ACTUATED AT LOW SPEED CLOCK "8Mhz", RED LIGHT.

*2 AS BATTERY BEING CHARGED RAPIDLY, ORANGE LIGHT.
AS STATUS OF LOW BATTERY, RED FLICKERING LIGHT.
AS BATTERY HAS BEEN COMPLETED, GREEN LIGHT.

*3 AS AC-ADAPTER IS USED OR CHARGING, RED LIGHT.
AS INPUT VOLTAGE OF AC-ADAPTER OR OUTPUT VOLTAGE
AT POWER-ON TIME IS ABNORMAL, RED FLICKERING LIGHT.

FIG.6

POWER SUPPLY CONTROL SYSTEM FOR A PORTABLE COMPUTER

This application is a continuation of application Ser. No. 07/541,978, filed Jun. 22, 1990, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to computers and, more specifically, the power supply of a portable battery operated computer. The invention includes both a system and the methods for controlling efficiently the power supply of such a portable computer.

As is known, recently computers have been developed which are convenient to carry. In conventional computers of these types, there are two primary methods for supplying the power. In one case, the power is supplied by an alternating current (AC) adapter. In the other case, the power is supplied by internal batteries. In these two methods mentioned above, the central processing unit, hereafter called "CPU", must always verify the status of the external power supply and the charge level of the internal batteries. However, in conventional methods and systems of these types, a single CPU also must control the voltages of the external power supply and internal batteries, and this creates a burden for one CPU. The presently known systems and methods for power supply control using one CPU are not efficient. Also, the known systems do not include any means for indicating to an operator the voltage or power supply status, such as whether or not the power is off.

SUMMARY OF THE INVENTION

Accordingly, an object of the invention is to efficiently control a chargeable power supply and current flowing from an AC adapter to internal batteries constantly.

A further object of the invention is to indicate the status of a power supply for a portable computer.

Still another object of the invention is to display the status of the power supply of a portable computer to the computer's operator, such as whether or not the power is off.

In accordance with one aspect of the present invention, the foregoing objects are achieved by providing a power supply control system for a computer having a central processing unit (CPU) and operable in response to power from a rechargeable battery or an alternating current (AC) adapter. The computer includes a charge circuit for controlling a power from the AC adapter to the rechargeable battery, and a power control microprocessor independent of the CPU for controlling the charge circuit, and a detector for supplying status signals representing a plurality of conditions associated with the AC adapter to the microprocessor, wherein the battery or the charge circuit, and the power control microprocessor includes a circuit for generating control signals to control the charge circuit in response to the status signal.

In accordance with another aspect of the present invention, a power supply control system for indicating the status of voltage and current in a computer system includes:

means for monitoring the status of the voltage from an AC adapter and at least one rechargeable battery, and the current flowing from current detectors, comparison means for comparing a detected voltage and current with a reference voltage and current, and means, coupled to a plurality of display elements, for displaying the status of voltage and current in response to the comparison means, whereby the display element shows a low battery state when the detected voltage is below the reference voltage and a voltage abnormality state when a voltage abnormality is present.

Other objects, features, and advantages of the present invention will become apparent from the following detailed description. It should be understood, however, that the detailed description and specific examples while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will be apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. **1** is a schematic block diagram illustrating a power supply control system with a power control circuit for use in a computer system, according to one embodiment of this invention;

FIG. **2** is a detailed diagram of the power control circuit of FIG. **1**;

FIG. **3**, **4** (*a*) and (*b*)are flowcharts illustrating control sequences associated with the power control circuit of FIG. **1**;

FIG. **5**(*a*) perspective top view of a computer system according to an embodiment the present invention;

FIGS. **5**(*b*) and **5**(*c*) show another perspective view of the computer system of FIG. **5**(*a*); and

FIG. **6** is a diagram illustrating how the operating states of the computer system are displayed in the LEDs used in conjunction with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a schematic block diagram illustrating a power supply control system with a power control microprocessor for use in a computer system according to one embodiment of this invention. As illustrated, computer system **1** includes various computer components, as follows.

A CPU **11** operates computer system **1** with programs stored in a ROM **12** and RAM **13**. ROM **12** stores a basic input or output system program, and RAM **13** stores application programs and data for use by an operator. A direct memory access controller (DMAC) **14** controls and sends data directly between RAM **13** and an input/output apparatus, for example, a hard disk drive (HDD) **20**A and a floppy disk drive (FDD) **32**, etc., apart from CPU **11**.

A programmable interrupt controller (PIC) **15**, a programmable interval timer (PIT) **16** and a timer module **17** having a real-time clock with a backup voltage (hereafter called "VBK") of +5 VDC are provided. An expanded RAM **18**, using particular card slots, provides VBK. A backup RAM **19** having display data therein stores the contents of a program counter for a currently-running program, various registers and a memory and I/O statuses, so that it can restart an interrupted job when repowered.

A hard disk pack **20**, which fits particular card slots, includes 2.5 inch hard disk drive (HDD) **20**A and a hard disk controller (HDC) **20**B. A floppy disk controller

(FDC) 20F controls access to floppy disk drive (FDD) 32 connected thereto. A printer controller (PRT-CONT) 21 controls access to a printer 34 connected thereto by a cable.

A universal asynchronous receiver transmitter (UART) 22 is a serial input/output interface, provided with a voltage VPH (+12 VDC) and a voltage VMH (+9 VDC). A keyboard controller (KBC) 23 controls access to a keyboard 36 connected thereto. A display controller (DISP-CONT) 24 controls display of data on an LCD 37. A video random access memory (VRAM) 25 is a refresh memory to store data to be displayed on LCD 37 or CRT display 38, and is provided with VBK. A kanji-ROM 26 is accessible by kanji character codes, and stores kanji character patterns.

A power supply interface (PS-IF) 28 controls a power supply control circuit 30 and is connected to CPU 11 via a system bus 10 (to be shown in FIG. 2 in more detail). An AC adapter 29 converts an AC voltage (+120 V) to a DC voltage (+12 VDC) and is plugged into computer system 1 via a DC-in-12 V pack. A main battery (M-BATT) 31*a* and a sub battery (S-BATT) 31*b* each includes a rechargeable battery (i.e., a nickel-cadminum battery) to provide 7-8 VDC, and may be a removable pack.

An external floppy disk drive (FDD) 33 may be connected to FDC 20F by a cable. An RS-232C interface unit 35 is connectable to a serial input/output interface UART 22 by a cable, and LCD 37 is connected to display controller 24. LCD 37 is provided with a voltage VLD (−22 VDC). An expanded connector unit 40 is connected to a system bus 10 and is connectable to expanded units (not shown) by a cable. Thus, there are several alternatives to choose.

FIG. 2 shows a detailed diagram of the power supply control circuit of FIG. 1. In FIG. 2, power supply control circuit 30 has a built-in 4-bit single-chip power control microprocessor (PC-microprocessor) 306, which may be a Toshiba module TMP47C440AF. Power control microprocessor 306 is constantly provided a power from M-BATT 31*a*. PC-microprocessor 306 includes a CPU, a RAM for storing data, and a ROM for storing a control program, for example, a program for calculating the remaining capacity of M-BATT 31*a*, i.e., a low battery state, and for including a low battery table, which is used to detect low battery states with a detected voltage and charging current. PC-microprocessor 306 controls power to the computer components of computer system 1 in accordance with a current state from a charge unit 311 to M-BATT 31*a* and a DC-DC converter 315, which current state is detected by current detectors 312 and 314, and an ON/-OFF state of power-switch 301, a reset switch 302, a display switch 303, and a mode switch 304. A parallel I/O interface 305 is connected to power-switch 301 and reset switch 302 for initializing the computer components of computer system 1. Display switch 303 supplies a power to LCD 37, and mode switch 304 is set the mode to actuate the expanded unit of computer system 1. Parallel I/O interface 305 holds the ON/OFF states of switches 301-304 and sends a value representing the ON/OFF states of these switches to PC-microprocessor 306 via an internal bus 307 or to DC-DC converter 315 and 319 directly.

A back-light controller 308 supplies a power to LCD 37 in response to a set of variable registers to control the intensity of back-light of LCD 37. An LED driver 309 controls an LED L1 for indicating the ON/OFF state of power switch 301 and the actuating speed of CPU 11 (as shown FIG. 5(*a*) in more detail), an LED L2 for indicating the capacity state of the battery (as shown FIG. 5(*a*) in more detail) and an LED L3 for indicating whether AC adapter 29 (of FIG. 1) is present (as shown FIG. 5(*a*) in more detail).

Each LED displays L1, L2 and L3 each may display three different colors (e.g., red, green, and orange as shown in FIG. 6 in more detail). For example, when the green light of LED L1 is on, CPU 11 is actuated at a high speed clock frequency of 10 MHz. When the red light of LED L1 is on, CPU 11 is actuated at a low speed clock frequency of 8 MHz. When the orange light of LED L2 is on, batteries M-BATT 31*a* and S-BATT 31*b* are charged rapidly. When the red light of LED L2 is flickering, M-BATT 31*a* is in a low battery state. When the green light of LED L2 is on, charging of M-BATT is completed. When the red light of LED L3 is on, AC adapter 29 (of FIG. 1) is in use or charging. When the red light of LED L3 is flickering, an abnormality is present in the input voltage of AC adapter 29, or in the output voltage at the power-on time, or in the self test of the power supply control circuit. A digital-to-analog (D/A) converter 310 converts a digital output signal from PC-microprocessor 306 to an analog charge control signal and sends the charge control signal to charge unit 311. Charge unit 311, which has a 256 bit DC-DC converter, charges M-BATT 31*a* in accordance with the charge control signal from D/A converter 310.

Current detector 312 detects a direct current to both M-BATT and DC-DC converter 315, 319, and a current detector 314 detects a direct current to DC-DC converter 315 alone. DC-DC converter 315 converts a DC voltage (+12 VDC) from AC adapter 29 or M-BATT 31*a* to a power supply voltage of, for example, +5 VDC, +12 VDC, −9 VDC and −22 VDC, to be supplied to computer system 1.

An analog-to-digital (A/D) converter 316 converts analog input voltages, which are associated with detected current of the current detectors 312 and 314, an output voltage of M-BATT 31*a*, the power supply voltages and the input voltage of the AC adapter, etc., to a digital voltage for PC-microprocessor 306. A/D converter 316 may have an 8-channel analog input terminal, so as to equally divide the input analog voltages into 255 sections. A serial I/O interface 317 communicates commands sent between PC-microprocessor 306 and CPU 11. A charge unit 318 charges S-BATT 31*b* and a DC-DC converter 319. DC-DC converter 319 converts a voltage from charge unit 318 and S-BATT 31*b* to VBK to be supplied to expanded RAM 18, backup RAM 19 and VRAM 25 (of FIG. 1).

FIGS. 3, 4(*a*) and 4(*b*) illustrate a flowchart of a control sequence performed by PC-microprocessor 306 (of FIG. 2), which will be described in detail below.

FIG. 5(*a*) is a perspective view of computer system 1 looking from the front thereof when a display cover 401 of computer system 1 is open. FIG. 5(*b*) is a perspective view of computer system 1 looking from the rear thereof, when display cover 401 is closed, As shown in an enlarged area A of FIG. 5(*b*), the edges of a push-button switch 301 on a side surface 405 of computer body 402 is surrounded by a protect wall la to prevent the operator from unintentionally pushing push-button switch 301 while carrying computer system 1, but allow the operator to intentionally push push-button switch 301 anytime. As shown in FIGS. 5(*a*) and 5(*b*), LED

displays L1, L2, and L3, etc., are disposed in an edge portion adjoining surfaces 1*c* and 1*d* of a rectangular block 1*b* and exposed regardless of whether display cover **401** is open or closed. Therefore, the operator can easily identify the operating states of the components of computer system **1**, even when display cover **401** is closed.

The flowcharts of FIGS. **3**, **4**(*a*), and **4**(*b*) describe a process whereby PC-microprocessor **306** (FIG. **2**) controls the power supply. PC-microprocessor **306** in power supply control circuit **30** (of FIG. **1**) detects the ON/OFF state of power switch **301** at all times. When power-switch **301** is off, PC-microprocessor **306** executes the power-off routine shown in FIG. **3**.

As shown in FIG. **3**, when power-switch **301** is on, the ON state of power switch **301** is held in parallel I/O interface **305** and a corresponding state signal is sent to PC-microprocessor **301**. PC-microprocessor **301** acknowledges the ON state of power-switch **306** in step **A13**. In steps **A14** and **A15**, the ON state of power-switch **306** is acknowledged. The time of switching-on power-switch **306** by the operator is detected, and then a counter CTR (not shown) increments one value (+1), and process steps of **A1** through **A15** are repeated until CTR counts to a predetermined value.

In step **A1**, it is determined whether the M-BATT's voltage exceeds 10 VDC. A signal representing M-BATT's voltage value at point C in FIG. **2** is sent to PC-microprocessor **306** through A/D converter **316**. If the determination in step **A1** is NO, PC-microprocessor sends a signal to activate a red light in LED L2 to flicker. LED driver **309** sends the signal through parallel I/O interface **305** in step **A2**, and the process returns to step **A1**.

If the determination in step **A1** is YES, it is determined in step **A3** whether AC adapter **29** is in use. The voltage value transferred to PC-microprocessor **306** through A/D converter **316** is anywhere between 0.4 VDC and 10 VDC. If the determination in step **A3** is NO, the process advances to step **A12**.

If the determination in step **A3** is YES, it is determined in step **A4** whether the voltage value supplied from AC adapter **29** is within a predetermined range between 11 VDC and 16 VDC. If it is outside the predetermined range, the process jumps to step **A2**. If it is within the predetermined range, the process advances to step **A5**, where PC-microprocessor **306** sends a signal to LED driver **309** through parallel I/O interface **305** to activate a red light in LED L3.

In step **A6**, it is determined whether a charge current supplied to M-BATT **31***a* from charge unit **311** is within a predetermined range between 680 mA and 340 mA, for example, by detecting a current at point C (of FIG. **2**) by current detector **312**, which detected current is transferred to PC-microprocessor **306** through A/D converter **316**. If the detected charged current is within the predetermined range then, in step **A7**, PC-microprocessor **306** sends a control signal to LED driver **309** through parallel I/O interface **305** to activate an orange light in LED L2 to flash when the detected charge current is within the predetermined range or to activate a green light in LED L2 to flash at other times representing an adequate charge capacity of M-BATT **31***a*, i.e., the time PC-microprocessor **306** detects the charging capacity "$-\Delta v$" of M-BATT **31***a*. By driving LEDs having multiple colors, the operational state of the computer system is indicated in detail even when display cover **401** is being closed.

If in step **A6** the detected charged current does not fall outside the predetermined range, it is determined in step **A8** whether the voltage of charge unit **311** at the point C in FIG. **2** is within a predetermined range between 5 VDC and 10.5 VDC. If it is not within the predetermined range, the process returns to step **A2**. If it is within the predetermined range, the process advances to step **A9**.

In step **A9**, it is determined whether the current of charge-unit **311** is higher than 680 mA, for example. If it is not higher in step **A9**, charge-unit **311** performs one step up in step **A11**. A voltage between 3.0 VDC and 11.0 VDC from charge unit **311** is divided by an integer **256** (called "one step") and is added to the voltage charging M-BATT **31***a*, in accordance with a control signal from PC-microprocessor **306** through D/A converter **310**. If it is higher in step **A9**, charge-unit **311** performs a one step down. In step **A10** the voltage charging M-BATT **31***a* is reduced by the one step in accordance with a control signal from PC-microprocessor **306** through D/A converter **310**.

When steps **10** or **11** are completed, in step **A12** it is determined whether display cover **401** is open or closed in accordance with a switch signal representing the ON/OFF state of display switch **303**, which signal is transferred to parallel I/O interface **305**. To detect the ON/OFF state of switch **303**, a line connecting switch **303** to parallel I/O interface **305** is set in advance at a signal high level "1". When display cover **401** is closed, switch **303** is activated to ground the line, thus changing the line's logical level from "1" to "0". If display cover **401** is closed in step **A12**, the process advances to step **A1**. If display cover **401** is open in step **A12**, the process advances to step **A13**.

The power-off-routine from steps **A1** to **A13** is repeated until the operator activates power switch **301**. In step **A13**, it is determined whether power switch **301** is being turned on. Step **A13** may be performed for example, for 0.4 sec. If it is, CTR counts up to a predetermined value N, and a power-on routine B (shown in FIGS. **4**(*a*) and **4**(*b*)) is performed.

As shown in FIGS. **4**(*a*) and **4**(*b*), the power-on routine commences in step **B1**. In step **B1**, PC-microprocessor **306** sends a control signal to converter controllers **326** and **328** through parallel I/O interface **305**. Converter controller **326** and **328** control DC-DC converter **315**, **319**, respectively, in accordance with the control signal, turn on switches **322** and **324** respectively at 0 VDC. Then, the power is supplied to the components of computer system **1**.

In step **B2**, it is determined whether expanded unit **40** is connected to expanded connector unit **40** and its power switch is turned on in accordance with a switch signal representing the ON/OFF state of mode switch **304**, which signal is provided to parallel I/O interface **305**. If the determination in step **B2** is NO, the expanded unit **40** is not used by the computer. If it is determined in step **B2** that the state of mode switch **304** is ON, expanded unit **40** is used by the computer then it is determined in step **B3** whether DC-DC converter **315** supplies predetermined voltages of, for example, +5 VDC, +12 VDC, −9 VDC, and −22 VDC to the computer's components, which voltages are sent to PC-microprocessor **306** through A/D converter **316**. If the determination in step **B3** is NO, then as in step **B26**, PC-microprocessor **306** sends a signal to LED driver **309** through parallel I/O interface **305** to activate LED L3 to flicker red light.

If the determination in step B3 is YES, then as in step B4, PC-microprocessor 306 outputs a system reset signal to a system reset controller 330 through parallel I/O interface 305, and system reset controller 330 in turn sends the system reset signal to CPU 11. CPU 11 sets up the computer's components in response to the system reset signal.

In step B5 as in step B3, it is determined whether DC-DC converter 315 supplies predetermined voltages to the computer components. If the determination in step B5 is NO, the process skips to step B26. If the determination in step B5 is YES, it is determined as in step B6 whether CPU 11 has sent a command to PC-microprocessor 306 through PS-IF 28 (of FIG. 1) and serial I/O interface 317 (of FIG. 2).

If the determination in step B6 is YES, it is determined as in step B7 Whether the command is a "System Power Off Command". If the determination in step B7 is YES, the process skips to step B27 where a system power-off process is performed, which is described in detail hereafter. If NO in step B7, PC-microprocessor 306 determines as in step B8 whether the command is a "back light ON/OFF request." If the determination in step B8 is YES, PC-microprocessor 306 sends a "turn off signal" to back-light controller 308 through parallel I/O interface 305, and back-light controller 308 turns off the back-light in response as in step B9, and then the process advances to B11. If the determination in step B8 is NO, it is determined as in step B10 whether AC adapter 29 is in use. If it is in use, a red light or red flickering light in LED L3 is activated in accordance with an output control signal from PC-microprocessor 306 as in step B10. Also, PC-microprocessor 306 sends a low battery state signal to CPU 11 through S10 interface 317. When a POPUP menu on the display 37 is called, the amount of power remaining in M-BATT 31*a* is displayed as one of seven-levels.

If the determination in step B6 is NO, it is determined in step B11 whether a value representing the current from charge-unit 311 (detected by current detector 312) and a value representing the current from M-BATT 31*a* to DC-DC converter 315 (detected by current detector 314) are transferred, i.e., the current value detected by current detector 314 subtracted from the current value detected by current detector 312 is within a predetermined range between +255 mA+10%, for example. If the determination in step B11 is NO, it is determined as in step B12 whether the current value from M-BATT 31*a* is abnormal for the system, i.e., M-BATT 31*a* may not be charged up. If YES in step B12, as in step B26, LED L2 is system activated to flicker red light. If NO in step B12, as in step B13, charge-unit 311 performs the same steps as in steps A8–A11.

If the determination in step B11 is YES, as in step B14, it is determined whether the state and the manner for calculating the amount of the remaining power of the remaining capacity of M-BATT 31*a* is low. Detection of the low battery state and a method of calculating an amount of remaining power is explained in detail in a copending U.S. patent application Ser. No. 07,134,370 of the same assignee. PC-microprocessor 306 changes a low battery voltage value when the low battery state is detected, in accordance with the current and voltage from M-BATT 31*a*, so as to ensure accurate detection of the low battery state.

If the determination in step B14 is NO, the process skips to step B17.

If YES, in step B14, as in step B15, PC-microprocessor 306 determines whether the voltage from M-BATT 31*a* to DC-DC converter 315 is below the changed low battery value. If the determination in step B15 is NO, LED L2 is actuated to flicker red light in response to an output control signal from PC-microprocessor 306. Then as in step B17, it is determined whether AC adapter 29 is in use. If the determination in step B17 is NO, the process skips to step B20. If YES in step B17, as in step B18, it is determined whether the voltage from AC adapter 29 is 100 VDC or 0 VDC. If the determination in step B18 is NO, the process advances to step B26. If it is YES in step B18, as in step B19, LED L3 is activated to flicker red light in accordance with an output control signal from PC-microprocessor 306.

In step B20, it is determined whether the ON/OFF state of reset switch 302 is detected, which is transferred through parallel I/O interface 305. If the determination in step B20 is NO, as in step B22, it is determined whether the ON/OFF state of display switch 303 is detected, i.e., whether display cover 401 is open. If YES in step B22, the process returns to step B3. If NO in step B22, as in step B23, PC-microprocessor 306 determines whether the ON/OFF state of power switch 301 is detected. If a signal transferred through parallel I/O interface 306 is at a logical level "1", the process returns to step B3. If the signal is at a logical level "0", as in step B24, PC-microprocessor 301 confirms the ON state of the power switch and CTR increments by one (+1). In step B25, it is determined whether CTR has counted up to a predetermined value M. If NO in step B25, the process returns to step B3.

In step B15 or step B20 or B25, if the determination is YES, the process advances to step B21 and then step B27, wherein PC-microprocessor 306 sends the "System Power Off Request" to computer system 1, through serial I/O interface 317 and PS-IF 28. In response to the system power off request signal, CPU 11 sends an "ACK" to PC-microprocessor 306.

When PC-microprocessor 306 does not receive the "ACK" signal, it determines that abnormalities (e.g., a program overturn) are present in computer system 1, and performs power off sequence to protect HDD 20. When it receives the "ACK" signal, it waits for the "System Power Off Request" from CPU 11 for above a minute (above five minutes in lower battery state).

When PC-microprocessor receives the "System Power Off Request" from CPU 11, it returns the "ACK" signal to CPU 11. The CPU 11 interrupts the program currently running and saves the contents of RAM 13, RAM 18, the I/O statuses, the contents of the registers, etc. into backup RAM 19 having a memory capacity of, for example, 16K bytes. If FDD 32 or HDD 20A is accessed, the save operation is also performed after an access end is reached (Resume Function).

If PC-microprocessor 306 waits for one minute (or five minutes) but still does not receive the "System Power Off Command" from CPU 11, it sends a "Time Out Power Off Request" to CPU 11.

When CPU 11 receives the "Time Out Power Off Request," it returns the "ACK" signal to PC-microprocessor 306 and performs the save operation as much as possible until the power is turned off. When the save operation is completed, CPU 11 sends a "System Power Off Command" to PC-microprocessor 306 and enters a halt (HLT) mode.

When PC-microprocessor **306** receives the system power off command, it returns the "ACK" signal to CPU **11**, cuts off the power to the computer components, and the process advances to the power-off routine.

As mentioned above, PC-microprocessor **306** performs the power off routine shown in FIG. **3**, when the power to the computer components is stopped, and performs the power on routine shown in FIG. **4**(*a*) and **4**(*b*) when the power is supplied to them.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefor to be understood that, within the scope of the appended claims, the present invention can be practiced in a manner other than as specifically described herein.

What is claimed is:

1. A power supply control system for controlling direct-current power from a rechargeable battery or an alternating current adapter to supply to a computer having a central processing unit, comprising:

charge circuit means, coupled to the adapter and the battery, for charging the battery;

means for coupling the adapter or the battery to the computer to transmit power thereto;

detection means, coupled to the charge circuit means and the battery, and generating status signals corresponding to a plurality of predetermined system conditions related to the operating status of at least the adapter and the battery; and

power control means separate from the central processing unit being coupler to the detection means, and generating control signals in accordance with said status signals to control the charging of the battery by said charge circuit means.

2. The power supply control system of claim **1**, wherein the computer includes a plurality of switches each of providing a predetermined function, and

the power supply control system further comprises input/output circuit means, coupled to said switches and the power control means, for detecting an ON/OFF state of each of the plurality of switches, and for providing a signal for each detected ON/OFF state, thereby controlling the operation of the power control means corresponding to the signal.

3. The power supply control system of claim **1**, wherein the computer includes a back-up RAM and a video RAM, and wherein the one or more rechargeable batteries include a main battery for supplying a main power to the computer, and a sub-battery for supplying a back-up power to the back-up RAM and the video RAM.

4. The power supply control system of claim **1**, wherein the charge circuit means includes a charge unit for controlling the output voltage of the adapter and the rechargeable battery, and

the power supply control system further comprises a digital-to-analog converter, coupled to the charge unit and the power control means, for providing an analog control signal corresponding to said control signals.

5. The power supply control system of claim **1**, wherein the detection means includes first means for detecting a direct current from the charge unit means to the rechargeable battery at the power-off time of the computer and second means for detecting a direct current to the computer at the power-on of the computer an third means for detecting a direct current from the charge unit means and the rechargeable battery and forth means for detecting a direct current from the rechargeable battery as the AC adapter is not plugged-in, and

the power supply control system further comprises an analog-to-digital converter, coupled to the detection means, for providing a digital signal corresponding to a detected current; and

said coupling means including a direct current-direct current converter, coupled to the detection means and the rechargeable battery, for providing the power of the computer.

6. The power supply control system of claim **1**, further comprising:

internal bus means for transmitting signals between the detecting means and the power control means and between the power control means and the charge circuit means.

7. The power supply control system of claim **6**, further comprising a serial input/output interface means for changing parallel data to serial data,

wherein the computer has a system bus coupled to the central processing unit of the computer, the internal bus means is connected to the power control means and the serial input/output interface means, and the serial input/output interface means is coupled to the system bus to communicate with the central processing unit of the computer, such that the operation of the power control means is not affected by the clock speed of the central processing unit of the computer.

8. A power saving system for indicating a status of voltage and current in a computer to an operator, the computer having a power-switch, comprising:

means for controlling the power regardless of turning the power-switch on or off;

means for detecting an output voltage of an alternating current adapter and a rechargeable battery, and a current into one or more current detectors coupled to the adapter;

means for providing a reference voltage and current;

means, coupled to the detecting means, for comparing the detected voltage and current with the reference voltage and current; and

means, coupled to the comparing means, for displaying the status of voltage and current in the computer to the operator in accordance with a result of the comparison such that the display means displays a voltage abnormality status whenever a voltage abnormality is present.

9. The power saving system of claim **8**, wherein the display means includes an LED device capable of displaying at least two different colors for displaying information representing at least three different kinds of status.

10. The power saving system of claim **8**, wherein the display means includes a driver circuit coupled to the comparing means for controlling the displaying of the status of voltage and current in accordance with the result of the comparison.

11. The power saving system of claim **8**, wherein the computer includes:

a main body having a plurality of operative components each having a predetermined function;

a display cover having a closed position against the main body and swingable away from the body to an open and viewable position for displaying information;

the displaying means includes means for displaying an operative status of the operative components to the operator at times when the display cover is open or closed.

12. The power saving system of claim 8, further comprising means, coupled to the detecting means, for changing the reference voltage and current in accordance with the detected voltage and current.

13. A computer system for controlling direct-current power from a rechargeable battery or an alternating current adapter, comprising:

a data processing assembly including:

a central processing unit,

program storage means for storing programs for controlling the central processing unit and for storing data processing results,

a backup memory for storing data during a save operation,

a keyboard for inputting data and commands, and means for displaying the data processing results and a status of the direct-current power; and

a power supply control means including:

charge circuit means, connectable to the altrnating current adapter, for controlling a power from the alternating current adapter to the rechargeable battery,

power supply means, coupled to the charge circuit means and the rechargeable battery, for providing a power from one of the rechargeable battery and the charge circuit means to the computer,

detection means, coupled to the rechargeable battery and the charge circuit means, for detecting a status of power from one of the rechargeable battery and the charge circuit means to the power supply means, and for generating a signal associated with the power status, and

power control means, coupled to the detection means and to the data processing assembly, for controlling the charge circuit means for controlling the power in accordance with the signal.

14. An apparatus for controlling a power to a computer having a power switch for indicating an operational state of the computer and display switch for indicating an open or closed state of display cover, comprising:

means for detecting a state of said power;

means for determining an operational state of the power switch and display switch;

means, coupled to said determining means, for counting a predetermined time corresponding to a determined operational state of the power switch; and

means, coupled to said detecting means for inhibiting to change a detected state of the power whenever the closed state of the display cover is determined.

15. The apparatus of claim 14, wherein said determining means includes parallel input/output interface means for detecting a logical state of the power switch and display switch, and means for supplying the logical state of the power switch and display switch through the parallel input/output interface means,

further comprising power control means, coupled to the determining means, for providing the operational state of the power switch and display switch in accordance with the logical state of the power switch and display switch.

16. The apparatus of claim 14, wherein said counting means includes a carry counter.

17. A method for controlling a power from a rechargeable battery or an alternating current adapter to a computer having a central processing unit, a power switch for indicating an operating state of the computer, means for charging the rechargeable battery with a charging current from the alternating current adapter, and power control means for controlling the charging of the rechargeable battery, comprising the steps of:

detecting a status of said charging current and power;

controlling said charging current in accordance with the detected status;

determining an operational state of the power switch

counting a predetermined time corresponding to the determined operational state; and

changing the detected power after counting the predetermined time.

18. The method of claim 17, wherein the controlling step includes:

detecting an output voltage of the charge unit;

comparing the detected output voltage with a reference voltage; and

indicating a voltage status of the charge unit in accordance with a result of the comparison.

19. The method of claim 17, wherein the controlling step includes:

detecting the charging current;

comparing the detected charging current with a reference current; and

changing an output voltage of the charge unit in accordance with a result of the comparison.

20. The method of claim 19, wherein

the output voltage changing substep includes increasing the output voltage of the charge unit whenever the detected current is higher than the reference current, and decreasing the output voltage whenever the detected current is lower than the reference current.

21. The method of claim 17, wherein the controlling step includes:

detecting a current from the charge unit to the rechargeable battery;

comparing the detected current with a reference current; and

indicating a status of current of the charge unit whenever the detected current is within a predetermined range.

22. The method of claim 17, further comprising the steps of:

detecting a power capacity of the rechargeable battery;

comparing the detected capacity with a reference value; and

indicating a status of power capacity of the rechargeable battery in accordance with a result of the comparison.

23. The method of claim 17, further comprising the steps of:

detecting an input voltage of the alternating current adapter;

comparing the detected input voltage with a reference voltage; and

indicating a status of input voltage of the alternating current adapter in accordance with a result of the comparison.

24. The method of claim 18, 21, 22 or 23, wherein the indicating step includes generating a light control signal representing the operating state of the computer and

providing the generating control signal to a display medium.

25. The method of claim 24, wherein said control signal generating substep includes displaying information associated with the light control signal in at least two different colors.

26. The method of claim 17, further comprising the steps of:

comparing the counted certain value with a reference value; and

controlling said power to the computer in accordance with a result of the comparison.

27. The method of claim 17, wherein the computer includes a a display switch for indicating an open or closed state of a display cover, the method further comprising the steps of:

determining the state of the display switch;

inhibiting the changing step from changing the detected power whenever the closed state of the display switch is determined.

28. A method for controlling a power to a computer having input terminals for the power from a rechargeable battery or an alternating current adapter, a central processing unit for processing data, a power switch for indicating an operating state of the computer, and a power control means for controlling the power, comprising the steps of:

first determining whether specified commands are being received from the central processing unit of the computer;

detecting an operational state of the power switch;

counting a predetermined time corresponding to the operational state; and

changing the power after counting a predetermined time or after the receiving specified commands.

29. The method of claim 28, wherein said computer has a back-light, and wherein the first determining step includes:

determining whether the power control means has received a back-light-off command to turn the back-light off or a system power-off command to turn the power off, and

further comprising the step of generating a signal corresponding to the back-light-off command in response to the determination of the receipt by the power control means of the back-light-off command.

30. The method of claim 28, further comprising the steps of

determining a status of a charging current from the alternating current adaptor to the rechargeable battery;

controlling the charging current in accordance with the determination of said status of the charging current; and

determining a status of a discharging current from the rechargeable battery to the computer; and

indicating the determined status of a discharging current.

31. The method of claim 28, further comprising the steps of

determining a power capacity of the rechargeable battery;

comparing the determined capacity with a reference value;

determining said status of the power in accordance with a result of the comparison,

indicating said status of the power.

32. The method of claim 31, further comprising the step of transmitting a power-off request signal from the power control means to the central processing unit of the computer whenever the determined power capacity is below the referenced value.

33. The method of claim 28, further comprising the steps of:

detecting an input voltage of the alternating current adapter;

comparing the detected input voltage with a reference value; and

indicating a state of the input voltage of the alternating current adaptor in accordance with a result of the comparison.

34. The method of claim 30, 31, or 33, wherein the indicating step includes generating a light control signal representing the operating state of the computer by the power control means to a display medium through a parallel input/output interface.

35. The method of claim 34, wherein the light control signal generating substep includes displaying information associated with the light control signal in at least two different colors.

36. The method of claim 28, further comprising the steps of:

transmitting a power-off request signal to the central processing unit of the computer after counting the predetermined time;

interrupting a running of programs by the central processing unit of the computer;

saving information necessary to restart the interrupted program by the central processing unit of the computer;

transmitting a power-off command signal from the central processing unit of the computer; and

effecting the termination of said power to the computer.

37. A power supply control system for controlling direct-current power from a rechargeable battery or an alternating current adapter to a computer having a computer body and having a central processing unit for processing data, a power switch for indicating an operational state of the computer, comprising:

power supply circuit means, connectable to the rechargeable battery, or an alternating current adapter, for supplying said power of the computer including:

power control means, coupled to the power switch and the display switch, for controlling the power from one of the battery and the alternating current adapter independently of the central processing unit of the computer;

said power control means including means for determining the operational state of the computer;

means for providing a control signal in accordance with said operational state; and

means, coupled to the power control means, for controlling an ON/OFF state of the power supply circuit means in accordance with said control signal.

38. The power supply control system of claim 37, wherein the power supply circuit means includes a direct-current to direct-current converter, coupled to the means for controlling an ON/OFF state, for providing said power to the computer in accordance with a controlled ON/OFF state.

39. The power supply control system of claim 37, wherein the means for determining an operational state

includes means for determining whether the computer is in use.

40. A method for controlling a power to a computer having a computer body, a power switch in an ON or OFF state depending on whether the computer is powered on or off being connected to the computer body, a display cover having a closed position against the computer body and swingable away from the body to an open and viewable position, and a display switch in an ON or OFF state depending on whether the display cover is open or closed, comprising the steps of:

first determining an ON/OFF state of each of the power and display switches;

second determining an operational state of the computer;

generating a power-on control signal when the computer is powered off, the display is open, and the power switch is in the ON state in accordance with a result of said first and second determinations; and

changing the OFF operational state of the computer to the ON state in accordance with the power-on control signal.

41. A method for controlling a power to a computer having a computer body, a power switch in an ON or OFF state depending on whether the computer is powered on or off being connected to the computer body, a display cover having a closed position against the computer body and swingable away from the body to an open and viewable position, and a display switch in an ON or OFF state depending on whether the display cover is open or closed, comprising the steps of:

first determining an ON/OFF state of each of the power and display switches;

second determining an operational state of the computer;

generating a power-off control signal when the computer is powered on, the display cover is open and the power switch is in the ON state; and

changing the ON state of the computer to the OFF state in accordance with the power-off control signal.

42. A method for controlling power application to a computer having input terminals for power from a rechargeable battery or an alternating current adapter, a central processing unit for processing data, a power switch for indicating an operating state of the computer, continuously energized power control means for controlling power application to the computer and a detachable hard disk pack storing data to be processed by the central processing unit, the method comprising the steps of:

first determining whether specified commands are being received by the power control means from the central processing unit of the computer;

second determining whether the power switch is in an on-state or an off-state; and

changing the state of the power switch after receiving the specified commands, if the power is in the on-state.

43. The method of claim 42, wherein the first determining step includes determining whether the power control means has received a back-light-off command to turn the back-light off.

44. A method for controlling the operation of a computer, the computer including power control means controlling power application to the computer and having input terminals for power from an alternating current adapter or a rechargeable battery, a central processing unit for processing data, a first power switch for indicating an operating state of the computer, mode switch means for indicating whether an expanded unit is connected to the computer and a second power switch for indicating whether the expanded unit is turned on, comprising the steps of:

first determining whether the first power switch is in an on state;

second determining whether the mode switch is in an on state which indicates that the expanded unit is being used by the computer if the first power switch is in the on state; and

outputting a system reset signal to each of the computer components after an on/off state of the mode switch is determined, so as to set up the computer.

45. The method of claim 44, wherein the controlling method further includes the step of:

third determining whether predetermined voltages are supplied to the input terminals of the computer; and

operating the power control means to generate a light control signal to a display medium through an input/output interface, to represent the operating state of the computer if the third determining step determines that abnormal voltages are being supplied to the computer.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,239,495

DATED : August 24, 1993

INVENTOR(S) : NANNO et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

IN THE CLAIMS:

Claim 1, column 9, line 31, change "coupler" to --coupled--.

Claim 2, column 9, line 37, change "of" to --for--.

Claim 5, column 9, line 68, change "an" to --and--.

Claim 10, column 10, line 2, change "forth" to --fourth--.

Claim 13, column 11, line 23, change "altrnating" to --alternating--.

Claim 17, column 12, line 12, insert --;-- after "switch".

Signed and Sealed this

Eleventh Day of October, 1994

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks